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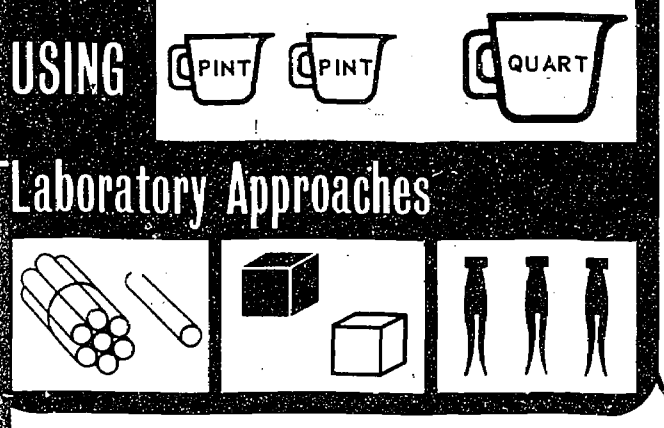
ABSTRACT

This pamphlet is a synthesis of the discussions that took place at a conference on the teaching of elementary mathematics using a laboratory approach. Presented is a definition of a laboratory approach followed by synopses on different settings for a laboratory approach, the role of the teacher, student produced materials and the use of activity cards in a laboratory approach. Disadvantages in laboratory approaches and the use of laboratory activities within a traditional setting are also reviewed. A list of references on laboratory approaches is included. (JP)

Teaching Elementary Mathematics USING Laboratory Approaches



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BACKGROUND INFORMATION

In recent years educators have grown increasingly interested in using laboratory approaches to teach mathematics. New York City has been a center of activity for experimenting with laboratory approaches. The personnel of the Madison Project have fostered the trend by conducting teacher inservice workshops and providing consultants for schools.

Some of the most articulate advocates of laboratory approaches are British. Laboratory approaches to teaching mathematics have been used in English primary schools for many years. The Nuffield Foundation Mathematics Teaching Project has trained thousands of English primary school teachers to use laboratory approaches. Miss Edith Biggs, in her role as one of "Her Majesty's Inspectors," has furnished inspired leadership for English teachers. Miss Biggs and James MacLean are authors of a book, Freedom to Learn (Addison-Wesley, Reading, Massachusetts, 1969), which should be studied by anyone seriously interested in laboratory approaches.

In order to assess the present status and future direction of laboratory approaches for teaching mathematics in elementary schools in New York State, an invitational conference was held this summer at the New York State Education Department in Albany. This conference was sponsored by the Bureau of Elementary Curriculum Development in cooperation with the Bureau of Mathematics Education and the office of ESEA Title I. The participants are active leaders in using laboratory approaches to teaching mathematics. The discussions which took place at the conference form the basis for this report, but the report is not intended as a transcription of the conference. This report does not attempt to describe all of the issues that were discussed. As expected, the participants were not in perfect agreement on many points. For this reason it should not be

assumed that they endorse all statements made here.

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A LABORATORY APPROACH?

The phrase, "laboratory approach," means many different things to different people. The conference discussions began with an effort to have the participants describe what they considered the essential features of a laboratory approach.

Though laboratory approaches are used in a variety of settings, the primary characteristic is a child, or small group of children, working independently, often using concrete materials, investigating some problem replete with possibilities for independent discovery of important mathematical concepts. Two examples on progressively sophisticated levels of discovery may help to illustrate the above point.

A small group of children may use loops of string and several sets of manipulative materials such as blocks to arrive at basic concepts in set development. Children may use these materials to illustrate such concepts as one to one correspondence, intersection of sets, union of sets, and subsets.

A small group of children have gathered together a collection of cylindrical containers. They investigate volume using sand and water. They wrap graph paper around the cylinders in an effort to approximate the area. They record data concerning heights, diameters,

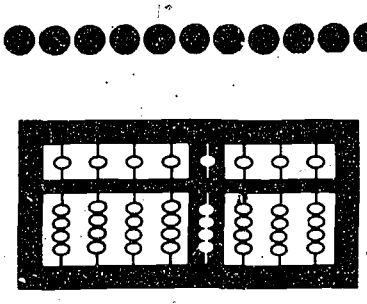
circumferences, volumes, and area. They tabulate and graph their findings. They draw hypothetical conclusions concerning relationships among volume, area, circumference, and diameter. A certain amount of direction is provided by the teacher (perhaps the suggestion has been made to measure circumferences and diameters) but the children are encouraged to think up their own questions.

It is evident that those who advocate such an approach are seeking to help children to become independent, confident thinkers. Children are provided many opportunities to:*

- . experiment freely with concrete materials
- . formulate hypotheses
- . test hypotheses
- . communicate findings

*I Do, and I Understand, Nuffield Mathematics Project, New York, John Wiley and Sons, 1967)

It is believed that this kind of experience is compatible with societal needs, educational objectives, and the recommendations of psychologists such as Jean Piaget. Educators who have visited classes, such as those in the Nuffield Mathematics Project, are impressed by other aspects of a laboratory approach - the children are interested, enthusiastic, and enjoy their mathematics lessons.



THE SETTING FOR A LABORATORY APPROACH

Ideally, a class using laboratory approaches has the needed facilities at hand, such as an extensive supply of visual manipulative materials, adequate storage spaces, space for displaying charts and graphs, worktables, measuring instruments, and file space for student records. Obviously, the ideal situation is rarely found. Educators have devised a variety of arrangements for using laboratory approaches:

A school may set aside a room or rooms for a mathematics laboratory. Children come to this laboratory at various times.

A central storage area may be provided for laboratory materials. Teachers check out these materials and return them when they are not being used.

Laboratory materials may be kept in carts which are moved from place to place as the need arises.

A teacher of a self-contained classroom adapts laboratory approaches to the needs of her pupils.

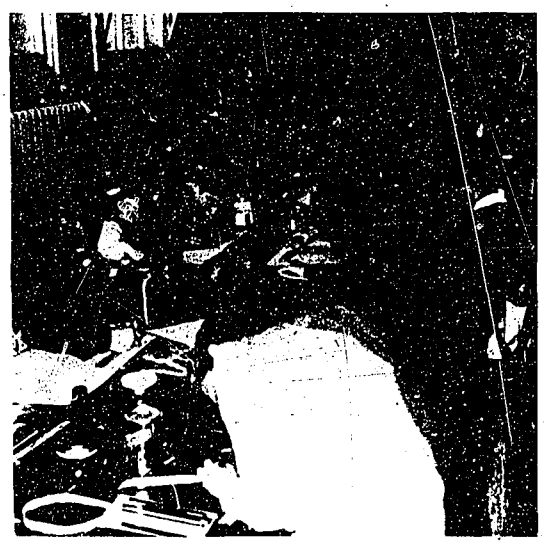
ROLE OF THE TEACHER

The conference participants were agreed that the teacher is the key to a successful use of laboratory approaches. A trained, enthusiastic teacher can establish an effective setting for laboratory approaches in spite of severely limited facilities. Visitors to the Nuffield Project in England have seen laboratory approaches used with success in overcrowded buildings built in the first half of the 19th century.

A critical point for a teacher is to avoid occupying the center of the stage as the source of all wisdom. Her role in a laboratory approach is one of participating with children in making discoveries. One of the most difficult tasks is to resist telling children what they are supposed to discover.

Observers of classes using laboratory approaches notice that teachers work exceptionally hard. Keeping track of 25 children who are working on different problems using a wide assortment of concrete materials keeps a teacher fully occupied. Providing guidance, and assessing and recording achievement in such a situation is extremely difficult. Yet, the teachers obviously enjoy the experience, and frequently endorse laboratory approaches enthusiastically.

Some systems have been able to recruit and train volunteers from among parents, secondary school students, and nearby college students who give one or two hours a week as mathematics laboratory aides. Such aides have proved very valuable in keeping track of projects done by the children and in helping them get over roadblocks they may encounter. A teacher using a laboratory approach needs to be prepared differently than a teacher who relies exclusively on textbook materials. She must be thoroughly familiar with the materials and the possibilities for mathematical learning. She must have developed a point of view which fosters uniquely individual effort on the part of the children. She must believe she can learn with the children. She is ready to recognize a valuable approach to a problem by a child regardless of whether she had anticipated it. In a sense, there are no wrong answers. Every response of children is worthy of respect and consideration.



The participants noted that laboratory approaches have particular value with disadvantaged children, especially those weak in verbal skills. Several instances were cited of non-English-speaking children who began working successfully and happily in a laboratory setting. Nonverbal children seem readier to talk with a teacher using laboratory approaches. The child comes to understand that no one will say his response is wrong. There is little pressure on children.

Since few teachers have had much experience with laboratory approaches either in their own schooling or in their teacher training, a strong program of inservice training is necessary for a school planning to utilize this approach in teaching mathematics. The conference participants, particularly Donald Anderson, David Clarkson, Don Cohen, Jane Downing, George Grossman, and Anne Peskin have been deeply involved in providing inservice training. They insist that teachers work with the same materials they will provide their children.

Teacher education institutions have taken note of the interest in laboratory approaches, and are providing more preservice and inservice training for teachers in this style of teaching. Two programs were cited to illustrate the availability of programs on different levels for teachers.

The School of Education of City College of New York has offered preservice sourses in laboratory approaches utilizing a workshop format where teachers work with concrete materials which will be used in laboratory settings.

At Teachers College of Columbia University a graduate program is offered on an inservice basis for practicing teachers. Here also, teachers have the opportunity to employ laboratory materials with children.

In addition, other teacher education institutions are in the process or have initiated mathematics courses which focus upon laboratory approaches.

A warning was issued by conference participants which was based on experience of a few years ago. A number of schools tried to introduce laboratory approaches simply by purchasing commercially prepared packages of concrete materials and distributing them to teachers. This does not work well. Most of these materials found their way to the back of closet shelves where they remain unused.

PICTORIAL REPRESENTATION

Observers of classes using laboratory approaches, particularly visitors to primary schools in England, are amazed at the skill children show in illustrating their investigations. They make extensive use of graphs, diagrams, and tables. Frequently, the walls of classrooms are literally covered with charts and graphs prepared by children. The skills associated with pictorial representation are obviously important. More than that there seems to be a strong motivational factor involved since the children take great pride in this part of their work.

One of the Nuffield Mathematics Project teacher guides, Pictorial Representation (John Wiley and Sons Inc., New York), gives an excellent idea of this aspect of a laboratory approach.

One of the conference participants voiced a warning about stressing records and pictorial representation. Some activities are not suitable to pictorial representation. Children should not be forced to make graphs, diagrams, and charts. Pictorial representation should be a natural, enjoyable culmination to an investigation, not a chore like the traditional term paper which frequently takes the pleasure out of reading the assigned books.

ACTIVITY CARDS

Among the most valuable aids for teachers inexperienced in laboratory approaches are activity cards, also known as assignment or task cards. These cards provide simple directions for starting an investigation, recording data, examining hypotheses, and communicating conclusions. It is important to keep them nonrestrictive, that is, open-ended. There is no doubt that they help ease the teacher's burden of lesson organization and preparation. Some classes using laboratory approaches operate with the children going to a file of activity cards, selecting a card, gathering materials and going to work, all quite independently.

Activity cards are available commercially but a teacher will adapt these to her own particular situation, and soon begin to prepare her own. The following is an example of a simple activity card:

> Get 36 discs. See how many different ways you can arrange these discs in rectangular arrays. Record your findings with pictures using graph paper. Keep a record of the "lengths" and "widths" of the rectangular arrays.

DISADVANTAGES

Most of the conference participants voiced objections to using the term, "disadvantages," Since they are strongly in favor of laboratory approaches, they tended to believe the advantages outweighed the disadvantages to the point of obliterating them. However, certain difficulties are evident:

Few teachers are experienced in laboratory approaches.

There is a need to acquire large amounts of concrete manipulative material and measuring devices. However, many materials can be obtained without cost; pie plates, boxes, bottle caps, cans, and plastic containers are but a few examples.

Few classrooms are well equipped for laboratory approaches. It is usually necessary to provide extensive storage facilities.

Some children not accustomed to working in a laboratory setting will need a somewhat lengthy period of adaptation to working independently.

Laboratory approaches are not very compatible with stress on the use of syllabi and standardized tests, but here it may be that the uses of the latter may need reconsideration.

Keeping track of individual student progress is difficult for a teacher.

Methods of reporting to parents other than check lists and grades will need to be used. The new methods of reporting progress may be developed through inservice education programs involving teachers who are following a mathematics laboratory approach.

There may be some teachers, and perhaps some children who will not function effectively using laboratory approaches.

LABORATORY AND TRADITIONAL APPROACHES

Traditional approaches stress the use of pencil, paper, and textbooks. It would be folly to claim there is no value in traditional programs. Many of the familiar processes and teaching techniques are relevant and important. There is a place for textbooks, for pages of practice problems, for teacher exposition, for drill on number facts, and for learning efficient algorithms. Most educators will begin using laboratory approaches on a small scale until they determine their appropriate place relative to their own situations.

GETTING ADVICE ON LABORATORY APPROACHES

Each of the participants will welcome inquiries from educators concerning laboratory approaches. In most cases they can arrange for visits to classes using a mathematics laboratories approach. In the New York State Education Department the Bureau of Elementary Curriculum Development and the Bureau of Mathematics Education can provide assistance to school districts interested in laboratory approaches. There is a growing supply of books, articles, films, and commercial manipulative materials available. The conference participants recommended a variety of materials for teacher study and use which are included as a part of this report.

If your school district provides pupils with mathematics laboratory experiences, share these experiences with the Bureau of Mathematics Education, Room 306, Albany, N.Y. 12224.

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Biggs, E. C. "Mathematics laboratories and teachers' centres, the mathematics revolution in Britain." The Arithmetic Teacher. 400-408. May 1968.

Biggs, E. C. & MacLean, J. R. Freedom to learn. Addison Wesley. 1969.

Compolo, Sister Marie. "Teaching geometry through creative movement." The Arithmetic Teacher. 576-578. November 1967.

Davidson, P.S. "An annotated bibliography of suggested manipulative devices." The Arithmetic Teacher. 509-524. October 1966.

Fitzgerald, William. "A mathematics laboratory for prospective elementary school teachers." The Arithmetic Teacher. 547-549. October 1968.

Hamilton, E. W. "Manipulative devices." The Arithmetic Teacher. 561-467. October 1966.

Marsh, L. G. Children explore mathematics. A. & C. Black. 1967.

Matthews, Geoffrey. "The Nuffield mathematics teaching project." The Arithmetic Teacher. 101-102. February 1968.

May, Lola. "Individualized instructioning learning laboratory setting." The Arithmetic Teacher. 110-112. February 1966.

May, Lola. "Learning laboratories in elementary schools in Winnetka." The Arithmetic Teacher. 501-503. October 1968.

Nuffield Guides. John Wiley. 1968.
Beginnings
Computation and Structure
I Do and I Understand
Mathematics Begins
Pictorial Representation
Shape and Size

Overholt, E. D. "A piagetian conservation concept." The Arithmetic Teacher. 317-326. May 1965.

Pethen. R. A. The workshop approach to mathematics. St. Martin's Press. 1967.

Rasmussen, Lore. "Countering cultural deprivation via the elementary mathematics laboratory, the low achiever in mathematics." United States Government Printing Office. 1965.

Sullivan, J. J. "Some problems in geometry." The Arithmetic Teacher. 107-109. February 1967.

Wahl, M. S. "Easy-to-paste solids." The Arithmetic Teacher. 468-471. October 1965.

Walter, Marion. "An example of informal geometry: mirror cards." The Arithmetic Teacher. 448-452. October 1966.

Williams, J. D. ed. "Mathematics reform in the primary school." Unesco Institute for Education. 1967.

Yeomans, Edward. "Education for initiative and responsibility." National Association of Independent Schools, 4 Liberty Square, Boston, Mass. 1968.